Risk Analysis, Vol. 21, No. 5, 2001

Perspectives

Hypothetical Fears and Quantitative Risk Analysis

Chauncey Starr[1]

Hypothetical fears are concepts, not quantities. Their conceptual nature makes impractical conventional quantitative risk analyses (QRA) based on benefit/cost/risk, so they become an unmeasured influence in national decision making. The decision process involves two steps, the Analytic Stage (QRA based) and the Priority Stage (resource allocation competition). This article suggests that a quantitative estimate of the social cost of fear reduction to acceptable levels be used as a surrogate QRA input to the Priority Stage.

KEY WORDS: Fear; risk; QRA; social cost

PREAMBLE

Why was I motivated to write this article? I am concerned that some hypothetical fears are being used to exploit public credibility, and the resulting political pressures may lead to disastrous long-term national policies. I believe that there is an urgent need for quantitative risk analyses to provide balanced insights to decision makers.

The philosophic underpinning of this article is best described in Barbara Tuchman's book, *The March of Folly*,[1] which explored the historical roots of four major social catastrophes—the fall of Troy, the Renaissance wars, the British loss of America, and Vietnam. Their causes were similar, arising from the amplification of a minor popular concern into an apocalyptic dogma by a political group, presumably to enhance its power. In each period, a few analytical thinkers carefully weighed realities (i.e., a precursor to benefit/cost/risk analysis) and disclosed the dogma's trap, but their voices were overwhelmed by the "cognitive dissonance" of a populace already convinced of the threat. In these historical cases, the penalties of the initially flawed policies led to decades of prodigious social and economic upheaval. Proving again that unforeseen consequences are the bane of all decision making.

[1] Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, CA 94304; cstarr@epri.com.

Today's public fears have a similar history. Fortunately, most small policy mistakes that may result from responding to minor public fears are eventually remedied by continuous adjustment, as inadequacies become evident. But some of today's hypothetical fear-based issues could develop into long-term doctrines that will be politically enduring, difficult to modify, and seriously destructive. Today's realities are that some very contentious hypothetical fears (e.g., global warming, radiation, and genetic modification) are already politically significant (nationally and internationally). The need for an early risk analysis of such large issues is clearly evident. The term "risk analysis" here signifies an in-depth, quantitative benefit/cost/risk analysis that includes a time line for potential effects.

INTRODUCTION

The inclusion of hypothetical fears in a quantitative risk analysis is made difficult by the absence of an empirical base. Fears become hypothetical when the guesstimate of either their probability, their consequences, or both has an indefinitely wide range of uncertainty. Because it is the product of these two that basically quantifies risk, the gross quantitative uncertainty becomes too large for a conventional risk analysis to be feasible. Yet, some risk analysis insight for

0272-4332/01/1000-0803$16.00/1 © 2001 Society for Risk Analysis

decision makers is clearly needed to avoid repeating the past history of catastrophic follies. In this article, I suggest a means for including hypothetical public fears in modified risk analyses useful to decision makers.

Quantifying such fears raises the usual question, "How safe is safe enough?" This is always the end objective of the risk analysis process intended to aid policy. The commonly overlooked question is, "safe enough for what?" Public health is the popular answer, but this is only one component of public welfare, which is a complex mix of political objectives (including, e.g., national security, economy, employment, and ecology, and relief of public anxiety). The policy-making process is always faced with the limitations of national resources (money, people, time, information, and public support). Resource allocation among many social needs is politically determined in practice by a judgmental comparison of the public welfare values of proposed alternatives for achieving the spectrum of political objectives—a process that is usually implicit and not quantitative, analytical, or transparent. If any alternative is too heavily weighted by hypothetical public fears, the decision response may be unwittingly flawed with serious consequences.

With such large uncertainty in evaluating such fears, politicians and single-cause advocates have an understandable reluctance toward considering risk analyses as applicable. For a confused issue, the usual political response is to try to outlaw its source—a step sanctified as the "precautionary principle." Hypothetical fears arise from a primitive instinct to suspect the unknown. Until there is certainty that there is no latent harm in an unfamiliar exposure, instinctively it is treated as a possible risk. This reaction leads to the precautionary principle. Realistically, this does not evade issue for long, and it doesn't remove the fear involved.

The precautionary principle is a retreat, not an answer. Carried to an extreme, the precautionary principle maintains the status quo by stopping economic and public health progress. For example, in the case of genetically modified crops and irradiated foods (where exploratory use and study has as yet revealed no harm), their contributions to the world's food resources are opposed by those who believe that in some unforeseeable manner they may damage our future environment. Even if well intentioned, the precautionary principle becomes a barrier to an adaptive future. A recent restaurant fortune cookie revealed a Chinese proverb: "Don't let doubt and suspicion bar your progress."

Fortunately for mankind's future, the gambling instinct seems to be as timeless and pervasive as the precautionary instinct. Eventually it overcomes the precautionary principle, because a society's status quo is rarely considered adequate. The tension between gambling and caution (i.e., benefits and risks) is expressed in the common cliche that "greed and fear" drives man's adventurism, exploration, and innovation. Greed usually wins, and, thus, new ventures are explored. Subsequent trial and error leads to a publicly accepted risk balance. As society becomes more complex and integrated, such empirical learning processes on a national scale involve large populations, large societal investments, and many decades. They have become enormously costly in terms of time, resources, and consequences. The inadequacies of our urban transportation systems are today a visible example of the costly burden of the trial and error approach. War is an extreme example of a trial and error resolution of international problems. Early risk analysis seems to be a wise alternative to trial and error.

FEAR IS A CONCEPT, NOT A QUANTITY

The fear paradox arises when a risk is imaginatively conceived, but its reality is not detectable or is not measurable. In every society, primitive or sophisticated, there are stimuli that arouse public fears of hypothetical dangers, vague and uncertain as they may be (e.g., asteroids). Such fears may arise from idle rumor, or scare-monger hyperbole intended to create public support for a cause. The fears then become a political reality, and may dominate public policies and world issues (e.g., biological and chemical warfare, mad-cow disease, suitcase bombs, terrorists, radiation, and foreign viruses.). These issues have not been in the usual domain of conventional risk analysis, and their study has primarily been the concern of the social sciences. So, how do we find a quantification measure?

My approach is to treat fears as mental concepts fundamentally capable of being defined and quantified as other are concepts, although not as precisely as scientists and engineers usually expect. Most quantitative input to risk analysis is derived from trial and error experience, rather than by direct study of cause and effect (the scientific approach). Trial and error has provided most of the knowledge base in the field of medicine. People accept medical practice because it usually works, even though it is mostly judgmental and probabilistic. Engineering, which describes how things work, is also mostly a trial and error art. Science seeks to disclose why things work, based on direct observation of cause and effect, but not all

science is so founded. Its most fundamental principles are almost all derived from the measurable effects produced by unseen causes (e.g., electromagnetism, gravity, and quarks). This provides science with an operational description of an originating cause, capable of being used for system analysis (e.g., force of gravity, electric and magnetic fields, and subatomic particles).

I believe this consequence measure may also be applied to hypothetical fears, well enough to be useful. The consequence that we can quantify is the probable social cost of minimizing the fear and its net effect on reducing resources for other public welfare needs. A social cost estimate need only be sufficient to disclose either an acceptable remedy or a gross folly. As a technique, such a formalized quantitative risk analysis is a low-cost simulation alternative to the trial and error approach. It avoids the irreversible costs of empirical trial and error practiced on a whole society.

THE ANALYTICAL CHALLENGE

How do we go about doing such a risk analysis? Most of society's fears are extrapolations either of the frequency of recorded rare events (e.g., asteroid impacts), or of known exposure risks at high levels projected to low levels (e.g., radiation). Frequent or high-level risks are obvious and measurable, and can be evaluated by conventional risk analysis. The policy choice for nondetectable risks is either to assume an extrapolation to the lowest levels or to accept a "threshold concept." When risks are very rare or nondetectable at low levels, a common practice is to designate a threshold that presumes no risk exists (or is equivalently trivial) below the designated level of exposure. There are precedents in public health where low-level quantities are essential for bodily functions, but are hazardous at high levels, so a risk threshold level exists (e.g., selenium) for some exposures.

For example, the well-known debate on the health effect of whole-body exposure to low-level gamma radiation has protagonists for each approach. The Linear Non-Threshold Theory (LNT) assumes that all radiation is harmful at every level. The empirical fact is that collected data does not show a measurable harm below some low level. The LNT implies that the effect is present but is hidden within the large population base. The threshold believers assume that below some practical level the effect is absent, or possibly may turn positive at some very low level. The question worth exploring is the practical difference in end results of such a choice, if indeed there is no detectable public health difference.

The difference as is significant only because reducing general radiation exposure as much as is physically possible results in very large expenditure of resources. To tackle this problem, we must recognize that proving the total removal of a risk is not conceivable, but that minimizing a risk to a designated level is feasible. This is the basic management response to any fear—measurable or hypothetical, individual or societal. Risk reduction requires the investment of financial or human capital, which increases exponentially as the risk reduction target is decreased. This produces a reasonable economic range for a threshold based on the cost per life saved as a function of risk probability.

Society's resources for public health are usually limited. Thus, society must consider the average value of one life saved as finite (e.g., transportation, war, and so forth). Thus, the governmental responsibility becomes one of resource allocation among a mix of opportunities, presumably based on comparative analyses. In-depth comparative analysis of multiple opportunities is such a complex task that it is rarely undertaken. As a simplified criterion, most societies suggest a rough financial limit on the investment justified to save one life, extend it, or improve its quality. This is the practical key that opens the door to a quantification role for the estimated minimization costs of conceptual fears.

There are two risk analysis stages involved in arriving at this commitment of resources. The *Analytic Stage* focuses separately on each risk that needs attention, and seeks the most efficient strategy among alternative methodologies for reducing it. The quantitative output of this process is a benefit/cost/risk analysis that shows the relation between reduction of a specific risk and the amount of investment allocated (e.g., lives saved per dollars invested, where "lives" is a surrogate for composite public health values). The *Priority Stage* focuses on the spectrum of risks that burden the government. It allocates national resources among these risks, seeking to holistically maximize public welfare. The Priority Stage process thus sets priorities, incorporating the information produced in the Analytic Stage. In principle, these two stages should be sequential. In practice, they tend to overlap.

THE FEAR PARADOX

In general, the political response to public fears originates with an implicit public concern with the visionary consequences of the feared event, leading to an explicit public consensus on how much of national

assets should be allocated to reduce this feared risk. The Priority Stage process leaves room for an overlay of social value to adjust the priority of a fear without regard to a risk analysis outcome. The quantitative arbiter is the social cost per life saved. This is not the same as the voluntary expenditure an individual might wish to make to extend his own life. In theory, the allocation to each health risk should be determined by an economically efficient distribution of society's budget in which each dollar spent helps to further optimize the collective welfare.

How much should society be willing to pay to protect an average person from harm? Crudely put, if $1,500 billion (one sixth of the Gross National Product) is our national annual budget to protect the health of 300 million people, that comes to $5,000 per person per year. Spread over the lifetime of an average person (optimistically, 100 years), this comes to $500,000 per lifetime. Obviously, some people will need more and some less during their lifetimes. A $1 million upper limit to save one average life should be ample, and may provide a guide for allocation decisions.

This is obviously too simplistic in a multivalued society, but it makes the point that excessive allocation (>$1 million per person) on minimizing any single lethality may damage the overall welfare by draining total health resources. For example, a billion dollars spent to reduce the risk of tumors from cellphones is a billion dollars that alternatively could be used to vaccinate children against measles, provide school lunches, or improve interstate highway safety. All of the latter have public health consequences much greater than cellphone-induced tumors (if such tumors exist at all). The various studies of expenditures in the United States to assure public safety show remarkable spreads in dollars per life saved, ranging from $50,000 to $800,000 for traffic safety, and $5,000,000 to $200,000,000 for radiation-related activities, including radioactive waste handling.

It is obvious that optimizing public health expenditures has not been a prime political concern and that public fears have played a significant role. Fear of radiation is an example of a minor public hazard being raised to a major issue by its proponents. For example, based on fear of radiation, Las Vegas, Nevada has just passed a city resolution against the transport of nuclear waste through its environs with the end statement " . . . even if scientists determine these fears are unfounded." Their concerns were really about the skittish tourists who might avoid the city. The radiation fear example illustrates that the moral high ground assumed by well-meaning activists for single health causes may well be socially immoral, when evaluated by the welfare of the total population.

CONCLUSION

Hypothetical public fears should be specifically incorporated in the information base considered in the Priority Stage. Recognizing the intangible nature of many public fears, quantification of the societal benefits of reducing them does not appear feasible. Therefore, Analytical Stage analysis should focus on estimating the investments needed to minimize such fears to an acceptable level. As discussed above, this provides an operational method of defining the magnitude of a fear, otherwise immeasurable.

When the cost of mitigation would result in a substantial drain on the resources available for improving public health, then the quantitative priority status of a fear shifts to the political and social arena of debate. It would be naive to assume that any quantified approach to society's decision making could supplant the traditional political processes. However, it is strongly evident to risk analysts that an insight to the probable social costs and consequences of a decision on managing a hypothetical risk would materially help to focus debate and provide a disclosure of the issues at stake. Comparative risk analysis provides a low-cost simulation tool to reveal the probable consequences of society's choices among alternatives. It is a "brain-power" substitute for the costly "trial and error" processes of government, and a reality check on hypothetical public fears.

ACKNOWLEDGMENT

This article was previously presented in its entirety at the Starr-Garrick Risk Symposium, held May 31–June 2, 2001 at the Beckman Center in Irvine, California.

REFERENCE

1. Tuchman, B. W. (1984). *The march of folly.* New York: Ballentine.